MATHCITYMAP – POPULARIZING MATHEMATICS AROUND THE GLOBE WITH MATHS TRAILS AND SMARTPHONE

Iwan Gurjanow[1], Joerg Zender[2] and Matthias Ludwig[1]
[1] Goethe University Frankfurt, Germany
[2] University of Applied Science RheinMain, Germany

Abstract. *For already over 40 years mathematics trails have been used in order to improve the attitude towards mathematics. With the availability of mobile devices, a new approach came into sight for mathematics trails and thus the MathCityMap project was founded. The projects started by reconstructing the workflow to create and walk a maths trail but then moved on to use the potential of mobile devices to create a completely new maths trail experience by elements of gamification, automatic feedback and communication. This paper describes the efforts of the project, evaluations and continuous development along with the needs of its users. The experiences, which are shared in the paper, may be useful for other initiatives to popularize mathematics.*

Key words: Maths trails, popularization, digital learning environment, MathCityMap

INTRODUCTION

Mathematics is a subject that polarizes students. Kollosche (2018) examined the perception of mathematics in an explorative study with 199 grade nine students. The results indicate that a big group of learners (about two-thirds) has a negative attitude towards mathematics, which is reflected by statements like “despair”, “stress”, “demotivation”, “depression”, “anxiety”, “exhaustion” and “headache” (Kollosche, 2018, p. 255). In particular, the students complained about a lack of emotions and discussions and furthermore find it hard to make sense of the learned content (Kollosche, 2018, p. 255). These findings might explain why mathematics is not the most popular topic among adults either. Various activities have been carried out around the world in order to improve the perception of mathematics and even the ICMI has held a whole conference solely on the topic of popularization of mathematics in Leeds 1989. For that conference Henry O. Pollak invited Dudley Blane, a mathematics educator from the Monash University, whom he had med during the ICME-5 in Adelaide (Pollak 2019, personal communication). On the ICMI topic conference in Leeds Blane (1989) reported on his activities in Australia to popularize mathematics with great success: He blazed maths trails. His first attempt was during a week of mathematics in offering an activity for families to discover the mathematics around them (Blane & Clarke 1984). Things went viral and suddenly mathematics trails have been blazed all over Australia and people like Edmund Hillary or the Governor-General of Australia started to support this kind of activities (Blane & Jaworski, 1989, Blane 1989). The idea of maths trails, originally intended for schools in the UK (Lumb, 1980), spread worldwide and even the ICME-7 in Quebec had an official maths trail during the conference as an activity for the participants (Gaulin, 1994). Eric Muller picked up the topic of mathematics trails for Canada and created the first deep gamified maths trails: The Welland Canal Math Trail (Muller, 1993a) and The Niagara Falls Math Trail (Muller, 1993b). The second one was printed like a newspaper, with measuring tape at the side of every page and handed out to tourists visiting the Niagara Falls as a sightseeing activity (see figure 1).

Gurjanow, I., Zender, J. & Ludwig, M. (2020). MathCityMap – Popularizing Mathematics around the Globe with Math Trails and Smartphone. In M. Ludwig, S. Jablonski, A. Caldeira, & A. Moura (Eds.), *Research on Outdoor STEM Education in the digiTal Age* (pp. 103-110). Münster: WTM. https://doi.org/10.37626/GA9783959871440.0.13

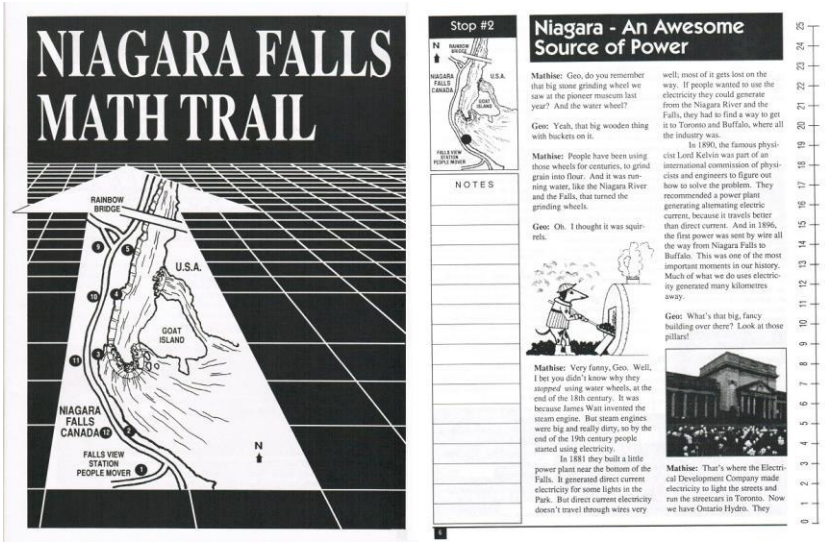

Figure 1: Two pages of the Niagara Falls Math Trail

As mentioned above, Pollak invited Blane to the topic conference in Leeds, where the word was spread, but furthermore, Pollak organized a teacher training in the USA in 1990 to which he also invited Blane (Pollak 2019, personal communication). Kay Toliver attended that training (Toliver, 2000) and developed a new way of going on a maths trail. She emphazised the idea of students creating the trail tasks instead of following an already set up trail (Toliver, 1993). A TV show was produced: "Good morning Miss Toliver" and she also got the founding for the first maths trail web portal www.nationalmathtrail.org[1]. Her work had an impact in the development of maths trails in the USA.

Meanwhile, the technological development has led to a massive spread of smartphones[2] around the globe that could be beneficial to the maths trail idea. The possibilities of a new technological approach in maths trails were introduced at ICME-12 (Jesberg & Ludwig, 2012) and the first results were presented on ICME-13 (Zender & Ludwig, 2016): the MathCityMap Project.

MATHCITYMAP AND THE POPULARIZATION OF MATHEMATICS

The MathCityMap (MCM) project combines the opportunities of a smartphone with the didactical ideas of mathematics trails. According to Shoaf, Pollak and Schneider (2004, p. 6) a "(…) mathematics trail is a walk to discover mathematics" and can be almost anywhere. The benefits of doing mathematics outdoors are based on the use of mathematical thinking in a carefree non-threatening environment (Shoaf, Pollak & Schneider, 2004, p. 5). Additionally, discussions about interesting problems and phenomena in small groups help to promote a positive stance towards mathematics and thus help popularize it. Originally, a real or a written guide helps to discover interesting mathematics in the local area. The MCM app for smartphones (available for Android and iOS) contains more than 1000 electronic maths trail guides from all over the world. Once downloaded, a maths trail can

[1] the site is archived here: https://web.archive.org/web/20090704044821/http://www.nationalmathtrail.org/
[2] in 2019 nearly 6 billion people have a mobile device, 4 billion of them have an internet connection (GSM Association, 2019)

be used even without an active internet connection. Furthermore, the app does not solely display the image and text of a task, but also offers dynamic hints, an automated answer validation and various modes of gamification (see figure 2).

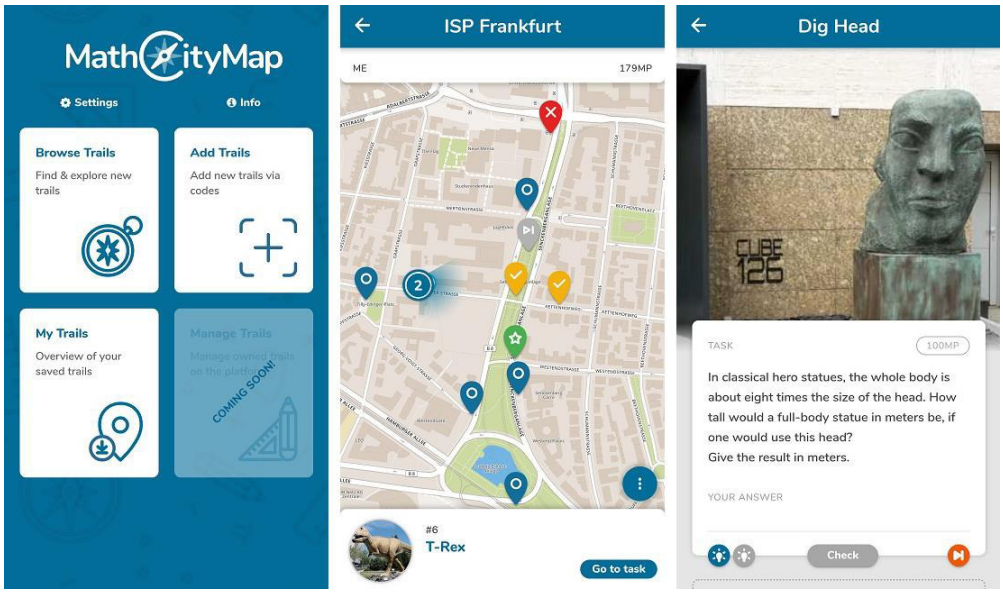

Figure 2: The MathCityMap Application for Smartphones.

Besides the MCM app, the MCM web portal (https://mathcitymap.eu) offers a handy tool for authors to create their own mathematics trails (see figure 3). Users can create tasks and trails by filling in a form to provide necessary data like the position of the object, an image, a task description, a sample solution as well as hints. Published contents are visible to all visitors of the web portal and can be included in own trails. This way the project tries to encourage people to blaze their trails, reuse task ideas, combine public tasks with own tasks to create new trails. A community of maths trailers has been established and is constantly growing.

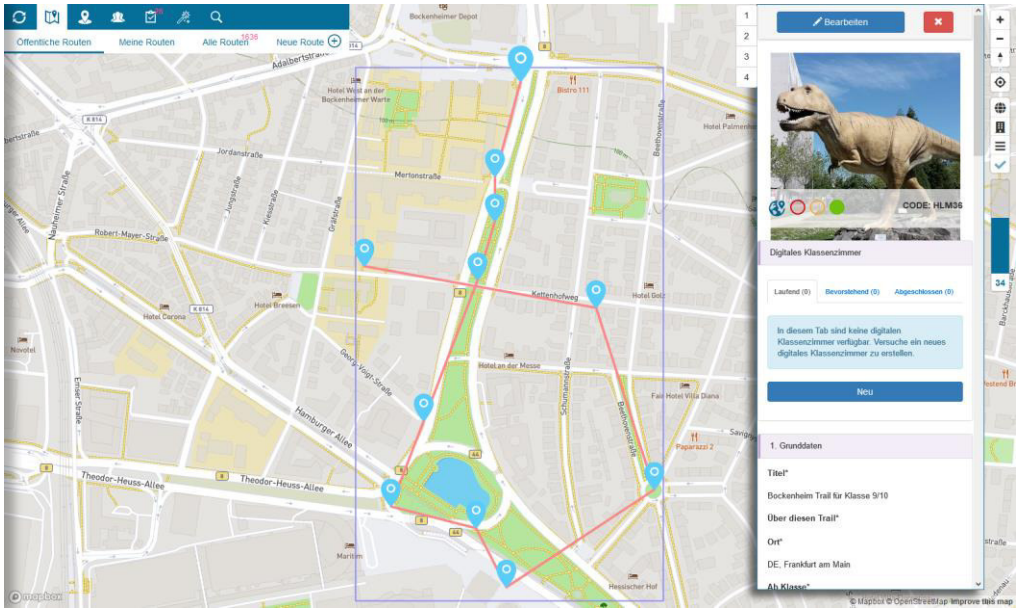

Figure 3: The MathCityMap Webportal.

Since the launch of the MCM project in March 2016, the team members have been strongly convinced that going on a maths trail can help popularize mathematics. Nevertheless, to establish a community of maths trailers, the idea of MCM itself had to be spread amongst the potential users. Team members took part in international conferences like ICME, CERME, EARCOME, ICTMA as well as national conferences and actively presented the idea of mathematics trails and the use of technology to a scientific audience. In addition, many teacher trainings that focused on the real implementation of maths trail in classes have been held. Gurjanow, Ludwig and Zender (2017) conducted the first survey among MCM users in 2017 to discover weaknesses of the system and learn more about the wishes the active users have. One major finding was the lack of material (e.g. best practice examples) that lead to not using the system. As a measure, we introduced a weekly-published article called "Task of the Week" that presented a best practice task, which can easily be implemented at other places. Also, a social media (in our case Twitter) strategy was developed and implemented. In 2018, the second user survey revealed that the taken measures were successful, since a lack of material was not reported anymore and the community growth increased (Gurjanow, Zender & Ludwig, 2018). In 2017, an Erasmus+ program was won with the help of seven European partners, who also support the idea of doing mathematics outdoors using modern technology. During the MoMaTrE[3] project the didactical ideas and the MCM software have been further developed. The app and the web portal have been translated into ten other languages. On the one hand, a professional software company is part of the consortium to pace the technological developments in that field. Bugs must be fixed fast to not lose users. In addition, new features require fast programming to get them in time. On the other hand, the Spanish Association of mathematics teachers (FESPM) is also part of the consortium and plays a big role in the dissemination of the project.
Annually user surveys and direct contact to the users during teacher trainings enable the MCM project team to have a feeling for what is the next step to take. Continuous development is one of the most important parts of the project philosophy. It is of vital importance to listen to the wishes and suggestions of the users.
Moreover, high standards are also held against users. The rules for publication are transparent and can be found in the web portal. Before a task will be made available to the public, it has to meet certain technical requirements and to pass a manual review process. This process ensures that published tasks are of high didactical quality and at the same time leads to a small professional development of the participating teachers (Jablonski, Ludwig & Zender, 2018).

New technical developments in maths trails

The first attempt of the MathCityMap Project was to digitalize mathematics trails. The next step was to create a benefit from using ICT. The first advantages were the automatic feedback and the hints the users could get from the app. In further development, the idea of gamification were picked up again for MCM (Gurjanow, Oliveira, Zender, Santos, & Ludwig, 2019). Shallow gamification came in form of scores and a leaderboard; the deep gamification came as a narrative for the trail. At the moment the trail blazer can choose a

[3] Mobile Math Trails in Europe: http://momatre.eu

pirate setting and the trail is completely changed into a pirate-style story of a treasure hunt (see figure 4). More themes are under construction and will be published within 2020.

Another new technological development is the digital classroom of MCM. It digitally represents the student groups of a classroom that are on a math trail with the MCM app in real time. Core features are the path tool, the chat and the event log. The path tool displays the positions of the participants on a map. The chat enables teachers to communicate with their students while they are solving math trail tasks to support their solution process or to organize the trail session. The event log keeps track of actions that students performed inside the MCM app, such as taking hints, solving tasks etc. The log can be used to evaluate the math trail in the following math lessons.

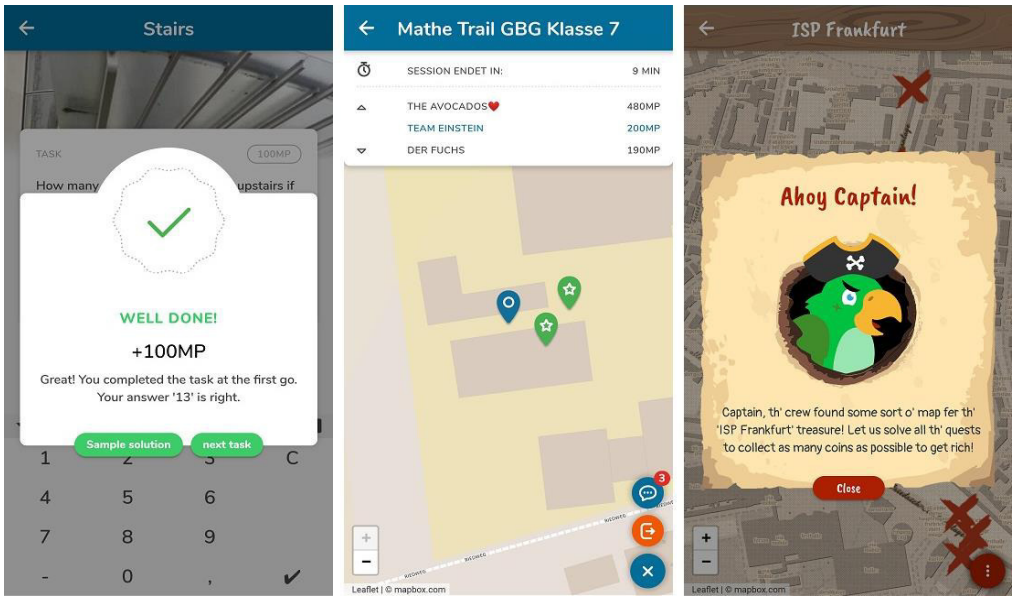

Figure 4: Shallow and Deep Gamification in the MathCityMap App.

The intention of the digital classroom is to provide the teacher a helping tool to organize a math trail as well as to regain control in the outdoor learning setting. Since the launch of the digital classroom in 2019, more than 400 sessions have been run with a peak of over 70 sessions in the month of June (see figure 5). The average number of groups per session is about 8.5, which leads us to an estimated number of 10500 students that were part of a digital classroom in 2019, since a group consists of three students.

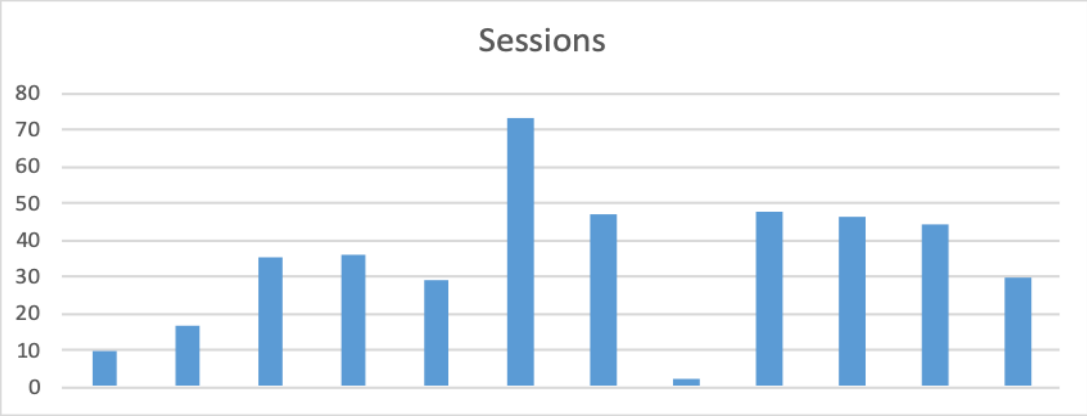

Figure 5: Monthly Number of Sessions in 2019 from January to December.

RESULTS

Summarizing the efforts, the MCM team gave mathematics trails a modern face by using the smartphone and web 2.0 technologies. A European network of mathematics education professionals who share the fascination of outdoor mathematics was established. The combination of the maths trail idea, a solid technical realization and a network of professionals lead to a growing number of users (see figure 6). In September 2019 (three years after the launch), there are over 3000 maths trails authors that created almost 10000 tasks world-wide. Over 440 mathematics trails have been reviewed by mathematics educators and can be freely used by everyone. The MCM app has been downloaded 25000 times. The growth of users is mainly focused on Europe so far, due to the MoMaTrE project. Nevertheless, a solid base has been established in Indonesia and South Africa and by the strong commitment of the Spanish teacher association, some decent first signs can be seen in Latin America.

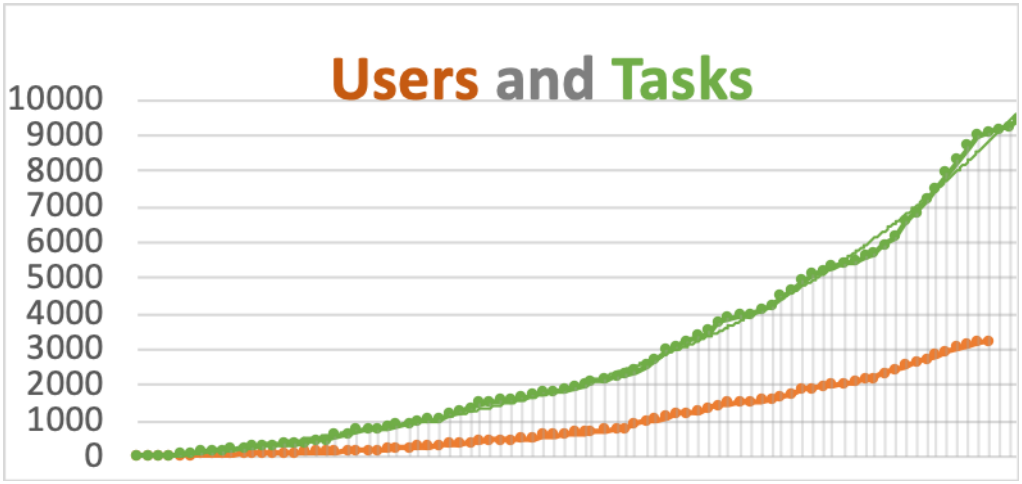

Figure 6: Number of Users and Tasks at the MCM web portal, from 1.3.16 to 01.09.19.

The MCM system could also win some reasonable prices in Germany, which mainly pushed the awareness and dissemination of the maths trail idea. The *Landmarks in the land of ideas* price was won in 2019[4], after the team was announced *Mathemacher des Monats* from the DMV in 2018[5]. In cooperation with the *Stiftung Rechnen*, a program called *Mathe.Entdecker* was founded[6]. The aim of the program is to provide high quality maths trails for families at chosen locations. For example, trails were created at the stock exchange in Stuttgart, at a science summer event in Kappeln (Northern Germany), at *Remstal Gartenschau 2019* in Schwäbisch Gmünd or in the center of Frankfurt am Main.

Finally yet importantly, some voices of the users on the question, why they use MathCityMap:

[4] https://land-der-ideen.de/en/project/mathcitymap-mcm-3896

[5] https://www.mathematik.de/des-monats/2350-mathcitymap-ist-mathemacher-des-monats-juni-2018

[6] http://stiftungrechnen.de/mehr-erleben/matheentdecker/

It helped to authenticate mathematics learning; Brought a lot of fun and life to mathematics learning", "It's interesting, exciting, challenging", "To connect mathematics with the environment", "to make student more active and love to study math", "To sensitize teachers that mathematics can be done anywhere. To show them how real-life examples from mathematics has a place in the curriculum. To foster interest among teachers.

The next step would be to get mathematics trails into the school curriculum, like it had been in Ireland (Government Publications 1999).

References

Blane, D. (1989). Mathematics trails. *ICMI Papers on The Popularization of Mathematics*. Leeds, UK

Blane, D.C. & Clarke, D. (1984). *A Mathematics Trail Around the City of Melbourne*, Monash Mathematics Education Centre, Monash University.

Blane, D., & Jaworski, J. (1989). Mathematics on the Move. *IMA Bulletin* 25, 114–116.

Gaulin, C. (Ed.). (1994). *Proceedings of the 7th International Congress on Mathematical Education*. Sainte-Foy: Presses de l'Université Laval.

Government Publications. (1999). *Mathematics – Teacher Guidelines*. Dublin, Ireland.

GSM Association. (2019). *The Mobile Economy 2019*. GSMA Head Office. United Kingdom.

Gurjanow, I., Ludwig, M., & Zender, J. (2018). Aids and Obstacles in the use of ICT - Two surveys amongst MCM Users. *Proceedings of the ICMI-EARCOME8*. Taipei (Taiwan).

Gurjanow, I., Oliveira, M., Zender, J., Santos, P. A., & Ludwig, M. (2019). Mathematics trails: Shallow and deep gamification. *International Journal of Serious Games*, 6 (3), 65–79.

Gurjanow, I., Zender, J., & Ludwig, M. (2017). What influences in-service and student teachers use of MathCityMap? In T. Dooley, & G. Gueudet, *Proceedings of the tenth congress of the european society for research in mathematics education* (CERME 10) (p. 2366-2374). Dublin, Ireland.

Jablonski, S., Ludwig, M., Zender, J. (2018). Task Quality vs. Task Quantity. A dialog-based review system to ensure a certain quality of tasks in the MathCityMap web community. In: H.-G. Weigand, A. Clark-Wilson, A. Donevska-Todorova, E. Faggiano, N. Grønbæk & J. Trgalova (Eds.). *Proceedings of the Fifth ERME Topic Conference (ETC 5) on Mathematics Education in the Digital Age (MEDA) 5-7 September 2018*, Copenhagen, Denmark, p. 115-122.

Jesberg, J. & Ludwig, M. (2012). Mathcitymap - make mathematical experiences in out-of-school activities using mobile technology. *Talk on the 12th International Conference on Mathematics Education*. Seoul.

Kollosche, D. (2018). Soziale Dimensionen der Wahrnehmung von Mathematik durch Schüler. In: G. Nickel , M. Helmerich, R. Krömer, K. Lengnink & M. Rathgeb (Eds.). *Mathematik und Gesellschaft. Springer Spektrum, Wiesbaden*, 249-258.

Lumb, D. (1980). Mathematics trails in newcastle. *Mathematics in School*, 9 (2), 5–5.

Muller, E. (1993a). Welland Canal Math Trail. Retrieved from http://spartan.ac.brocku.ca/~emuller/mathtrail/wcmt/wcmtstart.html

Muller, E. (1993b). *Niagara Falls Math Trail*. Ontario, Canada.

Shoaf, M., Pollak, H. & Schneider, J. (2004). *Math Trails*. Lexington: COMAP.

Toliver, K. (1993). The Kay Toliver Mathematics Program. *The Journal of Negro Education*, 62 (1), 35–46.

Toliver, K. (2000). *E-Conference Transcript with Kay Toliver April 27, 2000*. New York: Bell Atlantic Technology Education Center.

Zender, J. & Ludwig, M. (2016). Mathcitymap – A new approach of an old concept. *Talk on the 13th International Conference on Mathematics Education*. Hamburg.